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W, work of one pound of steam.

$\mathfrak{H}$ , expenditure of heat per pound of steam in foot-pounds.

$a=1109550$  foot-pounds.

$b=540\cdot4$  foot-pounds per degree Fahrenheit.

*Efficiency of steam,  $W \div \mathfrak{H}$ .*

*Exact Formulae.*

$$W = a \text{ hyp. log } \frac{t_1}{t_2} - b(t_1 - t_2) + v_2(p_2 - p_3).$$

$$\mathfrak{H} = a \left( 1 + \text{hyp. log } \frac{t_1}{t_2} \right) - bt_1 + J(t_2 - t_4).$$

*Approximate Formulae.*

$$W \div v_2 = p_1(17r^{-1} - 16r^{-\frac{17}{16}}) - p_3.$$

$$\mathfrak{H} \div v_2 = \frac{15\frac{1}{2}p_1}{r}.$$

In applying the exact formulæ, the relations between  $p$ ,  $v$ , and  $t$  may be found by means of known formulæ or Tables.

*February 3, 1859.*

Sir BENJAMIN C. BRODIE, Bart., President, in the Chair.

The following communications were read :—

- I. "On Platinized Graphite Batteries." By C. V. WALKER, Esq., F.R.S., F.R.A.S., &c. Received January 4, 1859.

In a short note communicated to the Royal Society on March 9th, 1857, and which was read on March 19th, reference was made to the voltaic combination that I had adopted for certain telegraphic purposes; namely, zinc-graphite. Graphite in its crude state had for some years been of great service to me, especially for batteries whose resting time is great in proportion to their working time. Since the date of that notice, I have considerably increased the value of graphite for electrical purposes by platinizing it according to the process first described by Mr. Smee, whose platinized silver battery has been long known and much used. The material to which I refer by the term "Graphite," is the crust or corrosion that is collected from the interior of iron gas retorts that have been long in use.

My first crude graphite battery of twelve pairs of plates was set up on April 5th, 1849, for working the telegraph from my residence at Tonbridge to the Telegraph Office about a mile distant. It was charged with sand saturated with diluted acid; and had not been dismounted in March 1851, when I changed my abode. During the interval, the sand was from time to time moistened with acid water or water only. The plates in this case had been roughly chipped out and rubbed on stone into something like shape. In the mean time I had some sets of plates cut at the Locomotive Works, Ashford, and was thus enabled to obtain further results. I forwarded a graphite battery to the Great Exhibition in 1851, for which a prize medal was awarded. The introduction of graphite into anything like general use was for a long period no easy matter, on account of the difficulty of finding any one who would undertake to cut it into plates, its hardness destroying the tools; and the then limited demand did not encourage any one to construct special machinery for the purpose. My wants at length reached the ear of Mr. J. Robinson of Everton, Liverpool, who took the matter thoroughly in hand, and has succeeded perfectly in cutting plates into any form and to comparatively any size, at a very moderate cost, for which I am much indebted to him. I have before me plates 12 inches  $\times$  10 inches, of smooth texture and uniform thickness, and have seen some of double that size.

The plates in common use for bell signals are  $7\frac{1}{2}$  inches  $\times$  3 inches and  $\frac{3}{8}$  inch thick, of which about 2000 are in daily use on the South Eastern Railway, and the greater portion of these are now platinized. The plates are delivered to me in their crude state, that is to say, they are merely cut into form. Immediately on arrival they are placed in a stone pan, and covered with a mixture of 1 sulphuric acid + 4 water, in which they are allowed to remain for three or four days or more. They are taken out as required, and are washed under a tap of running water; this operation dissolves out any foreign matter that might be pernicious in a voltaic combination wherein sulphuric acid was employed; they are then partially dried. A hole for a rivet is next drilled in the middle, near the top of each plate—a belt of varnish one inch wide is applied to the top on both sides of each plate—a blank one inch square, having the rivet hole for its centre, being left unvarnished on each side—electrotype copper is

then deposited on the blank square in the usual way. The deposited metal is then tinned, no part of the copper being left bare; a connecting slip of copper, 6 inches  $\times$  1 inch is prepared and also entirely tinned; this is riveted to the graphite plate with a copper rivet, also tinned. The soldering iron is now applied, and a little solder run in between the two surfaces. By thus protecting all the exposed copper with tin, the formation of sulphate of copper and its attendant inconveniences are prevented. The plate is now platinized.

A mixture of 1 sulphuric acid + 10 water is placed in a vertical glass cell, to this are added a few crystals of chloride of platinum till the solution presents a faint straw colour. The battery power employed for platinizing is three cells of platinized graphite and zinc. The positive electrode is platinum or graphite itself, and is presented to both sides of the plate that is to be platinized. The action is allowed to go on for about twenty minutes. Each finished plate is tested as to its power of liberating the hydrogen of electrolysis, by placing it in acid water in contact with an amalgamated zinc plate.

I have drawn out the above description in the presence of our assistant, who attends to this department of the telegraph establishment, in order to be correct in the small details.

The battery-cells for the plates above described are quart jars of stone-ware that resists acid. The exciting solution is 1 sulphuric acid + 8 to 12 water. Zinc plates are riveted to the other end of the copper connecting slip, also with tin rivets. The zinc is strongly amalgamated. It is dipped in a vessel containing 1 sulphuric acid + 4 water, and after a few seconds, more or less, is withdrawn and thrust in its then condition into a trough of mercury, and set aside to drain. On the following day it is treated in a similar manner. When the batteries are being put together, and before the zincs are placed in the jars, the foot of each is placed in a trough or slipper of gutta percha, 3 inches by  $\frac{1}{4}$  inch, containing about a couple of ounces of mercury. A battery thus carefully prepared will stand for an indefinitely long period with little perceptible waste, and be ready for use at all times. Under ordinary circumstances it is not necessary to dismount the batteries employed for telegraph signaling more than once a year. Mercury is added during the interval, and the jars are filled up as occasion requires. The greater portion of the mercury is recovered: when old plates come home, a considerable

quantity of rich amalgam is scraped from the plates; this is placed in jars of acid water, and a few pieces of graphite are thrown in; the electro-chemical action makes the amalgam poorer of zinc, and mercury is easily expressed. By continuing the operation, more mercury, to the amount in all of nearly three-fourths, is recovered.

As an illustration of the economic importance of this material in applied science, I am informed that the silver plates of the batteries constructed for the Atlantic Telegraph cost £2520 or more. On my having directed the attention of the Company to graphite as a substitute for silver, a set of plates were ordered, equal in number and size, which were supplied (furnished with electrotpe copper and connecting wires) for £216.

The following Table illustrates the effective working powers of platinized graphite, as compared, under like circumstances, with platinized silver, given in lifting powers in pounds, A third column is added, giving the results when table salt is dissolved in the water employed with the graphites.

Table I.  
Electro-magnet; 10 yards No. 16 wire.

12 cells in series.				12 cells in double series of 2 sixes.			
Resistance.	Silver.	Graphite.	Graphite.	Resistance.	Silver.	Graphite.	Graphite.
yds.	lbs.	lbs.	lbs.	yds.	lbs.	lbs.	lbs.
10	14.75	14	15	10	22.5	20.5	20
147	10	12.5	9	147	14	10	9
284	7	9	8	284	8.25	7	7
421	6	7	6	421	5	5	4
558	5	5	4	558	3.25	3	2.5
695	4.5	3	3	695	2	2.25	1.5
832	3	2.5	2.5	832	2	1.5	1.25
6 cells in series.				6 cells in double series of 2 threes.			
10		12.25	10	10	14	14	14
147	9	6.25	7	147	4	4	5
284	5	4	4	284	2.5	2.25	2.5
421	3.5	3	2.5	421	2	1.75	2
558	2.25	2	2	558	1.5	1.25	1
695	2	1.5	1	695	1	1	1
832	1.5	1.25	.75	832	.75	.75	.75

Table II.

Electro-magnet; 137 yards No. 16 wire.

12 cells in series.

Resistance.	Silver.	Graphite.	Graphite.
yds.	lbs.	lbs.	lbs.
137 × 2	14	18	22·5
137 × 3	12·75	15·75	14
137 × 4	10	13	11
137 × 5	9	12·5	11
137 × 6	9	10·75	11
137 × 7	9·5	9·5	9
137 × 8	8·75	9·5	8·75
6 cells in series.			
137 × 2	9·75	12·75	11
137 × 3	8	10·75	10
137 × 4	7·25	10	9·5
137 × 5	7·75	9	9
137 × 6	7	8	9
137 × 7	6·75	9	8·75
137 × 8	7	8·75	8
6 cells in double series of 2 threes.			
137 × 2	8·75	10	11
137 × 3	7·25	9	9
137 × 4	6	9	9
137 × 5	7·75	8	7
137 × 6	4·25	6	5
137 × 7	4	6	4·75
137 × 8	4·25	5	6

In all the above experiments the cells were charged with 1 sulphuric acid + 13 water (salt-water in the third column); and 13·5 square inches of surface were immersed. The silver-zinc pairs were 1 inch apart, the graphite-zinc, 2 inches. The lifting powers were not read off more closely than to quarter-pounds. The electro-magnet used in Table I. was a small horse-shoe containing about 10 yards of No. 16 wire; that used in Table II. was one of the electro-magnets used in the construction of the signal bells before described (*vide* Proc. Roy. Soc., vol. viii. p. 419), and containing 274 yards of No. 16 copper wire. The resistance added in each successive experiment was one bobbin of a similar electro-magnet or 137 yards of wire. The resistances in the Table include the resistance of the electro-magnet. The total resistances in Table II. are all multiples

of the contents of a single bobbin or 137 yards. A glance from left to right on the same horizontal line shows the comparative value of each combination in the several experiments. One or two small irregularities in Table II. in the six-cell results, are doubtless due to the poles of the magnet not having been ground true.

With respect to durability, the graphite plates in use since 1850 are in as good condition as the new ones now in course of manufacture. Silver plates employed by us under like circumstances, commenced perishing after twelve months or more of use; they crumble away in great measure, they cut apart at the surface level, and they get eaten into holes throughout.

II. "On the Aquiferous and Oviductal Systems in the Lamellibranchiate Mollusks." By GEORGE ROLLESTON, M.D., Lee's Reader in Anatomy, and CHARLES ROBERTSON, Esq., Curator of the Museum, Christ Church, Oxford. Communicated by Dr. ACLAND. Received January 6, 1859.

(Abstract.)

In this paper the authors bring forward two views as to the anatomy of the Lamellibranchiata.

1. The first part of the communication is devoted to an examination of the commonly-received opinion as to the outlet of the ovarian system, and arguments are brought forward to show that the orifices usually supposed to discharge this office are in reality the exhalant orifices of a water-vascular system. The positive arguments drawn from the way in which fine injections thrown in by these orifices distribute themselves throughout the visceral mass, and from the relative position of orifices acknowledged to belong to a water-vascular system in other mollusks, are confirmed by a consideration of the improbability attaching to the old view, which regarded as oviducts in mollusca two canals, which lying one on either side of the body, yet communicate freely with each other at no great distance from their termination, and which lie far away from the lower segment of the intestinal tube. The inhalant aquiferous orifices are considered to be indicated by a belt of parasitic animals impacted in the foot tissue, as represented in one of the figures.